The Interplay of Magnetic Fields, Fragmentation and Ionization Feedback in High-Mass Star Formation

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Massive stars disproportionately influence their surroundings. How they form has only started to become clear recently through radiation gas dynamical simulations. However, until now, no simulation has simultaneously included both magnetic fields and ionizing radiation. Here we present the results from the first radiation-magnetohydrodynamical (RMHD) simulation including ionization feedback, comparing an RMHD model of a 1000 M_sol rotating cloud to earlier radiation gas dynamical models with the same initial density and velocity distributions. We find that despite starting with a strongly supercritical mass to flux ratio, the magnetic field has three effects. First, the field offers locally support against gravitational collapse in the accretion flow, substantially reducing the amount of secondary fragmentation in comparison to the gas dynamical case. Second, the field drains angular momentum from the collapsing gas, further increasing the amount of material available for accretion by the central, massive, protostar, and thus increasing its final mass by about 50% from the purely gas dynamical case. Third, the field is wound up by the rotation of the flow, driving a tower flow. However, this flow never achieves the strength seen in low-mass star formation simulations for two reasons: gravitational fragmentation disrupts the circular flow in the central regions where the protostars form, and the expanding H II regions tend to further disrupt the field geometry. Therefore, outflows driven by ionization heating look likely to be more dynamically important in regions of massive star formation.

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